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(54) Abstract Title

Device for monitoring rate of change in liquid level

(57) A device 5 for monitoring the rate of change in the level of a liquid to detect fuel theft or leakage from vehicles comprises an input means, a processor (1-4, Fig.2) and an output means 6 eg an alarm or read out for indicating when the rate of change exceeds a defined threshold. The processor may hold and compare a number of time separated signals eg 10 - 100 milliseconds and may include comparison means for averaging signals. Activation of the device can be automatic when it detects the vehicle is not in use, and activation can be time delayed. The device can be connected between an information sender 2 and a vehicle fuel level readout 4. Diversion of the signal from a fuel level sensor 3 to the device or to a fuel level readout when the device is deactivated, and means for monitoring the level of the vehicle axis, may be provided.

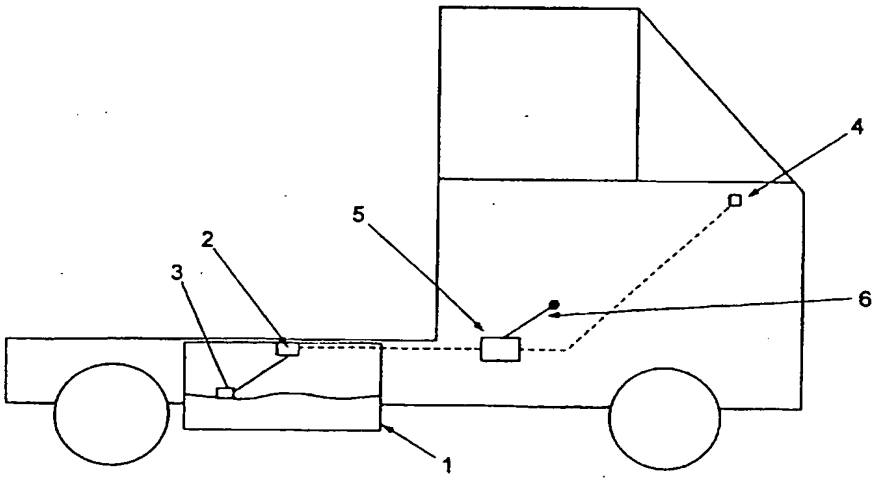

Fig. 1

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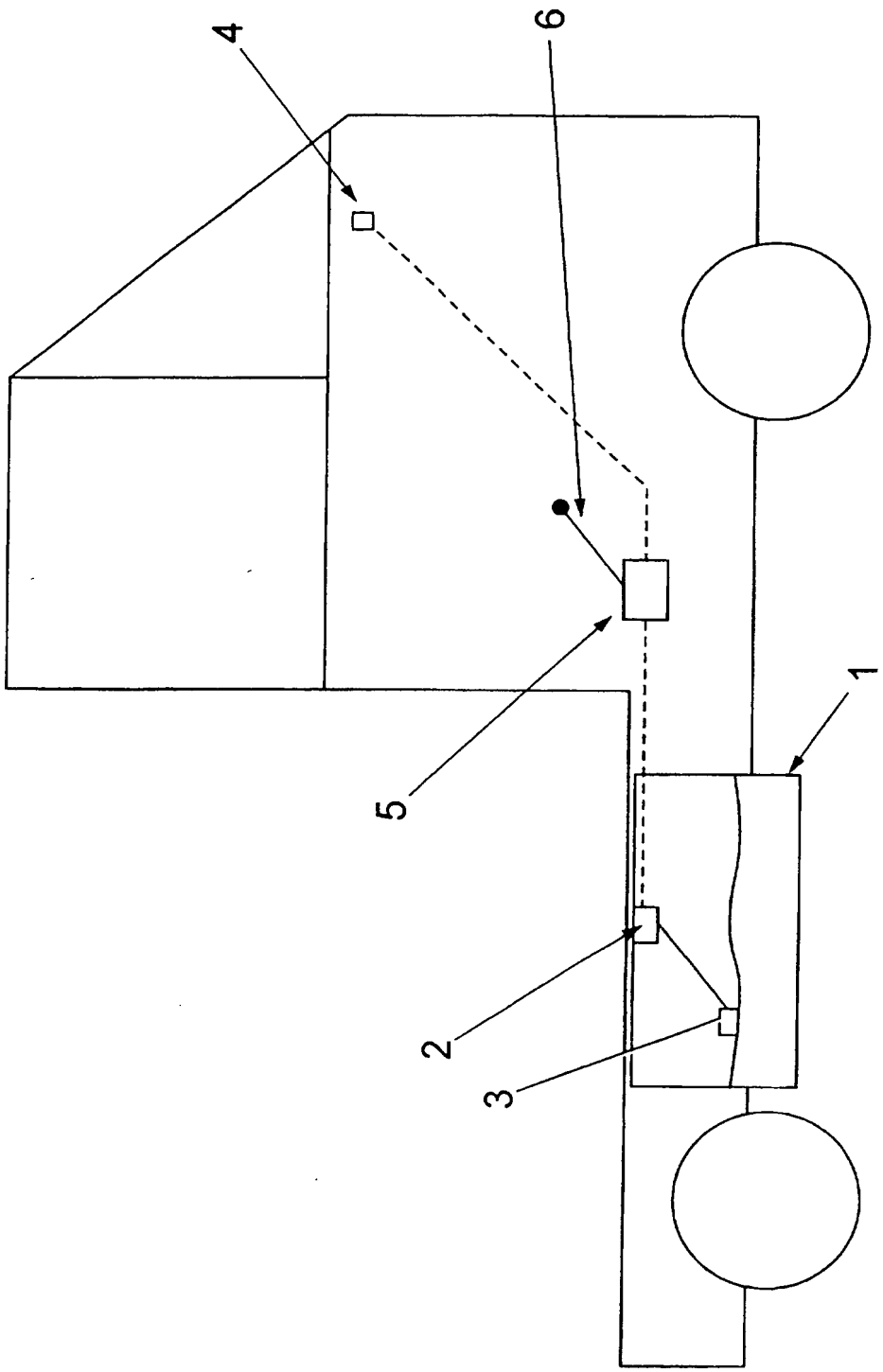

Fig. 1

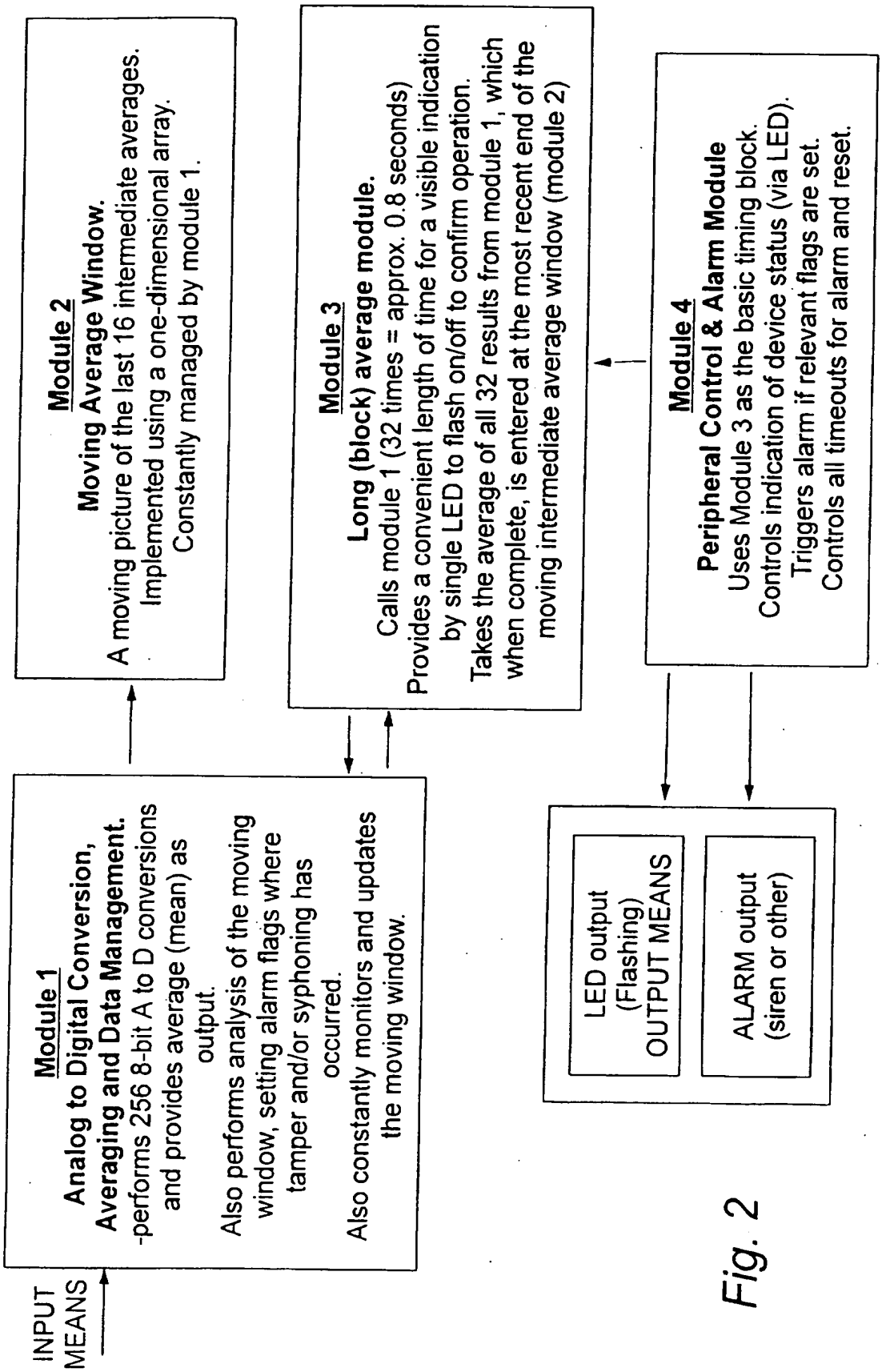

Fig. 2

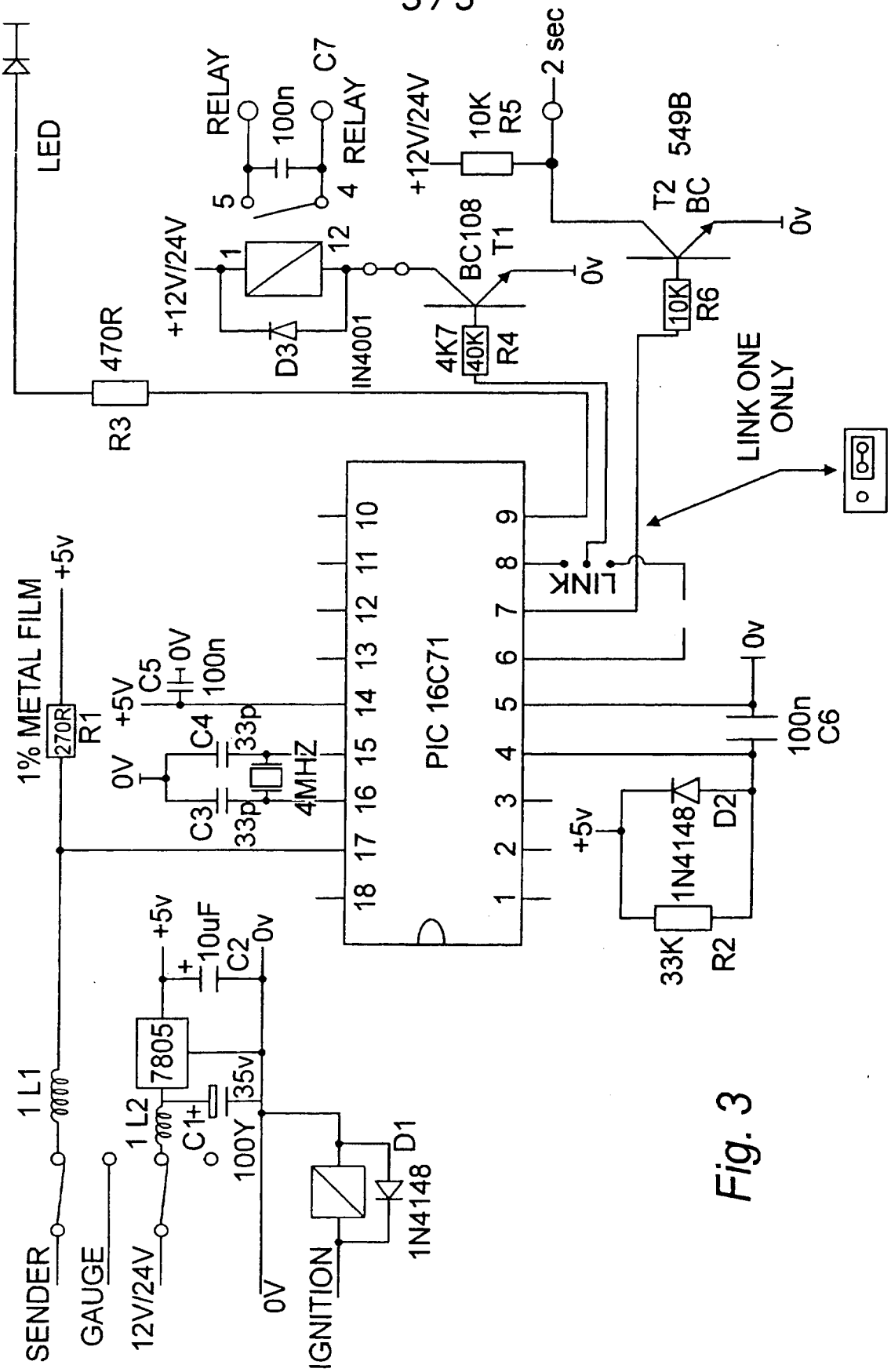

Fig. 3

DEVICE FOR MONITORING CHANGE IN LIQUID LEVEL

The present invention relates to a device for monitoring change in liquid level, a use thereof and a method of manufacture thereof.

The device has commercial applications in the areas of monitoring changes in liquid level both on an industrial scale, for example in the chemical industry, in the household, in fuel level of vehicles of all description such as trains, trucks, cars, buses, motorbikes, boats and aeroplanes and in monitoring of level liquid at municipal and other facilities.

A primary application of the present invention is in detecting fuel theft from vehicles. The theft of fuel from vehicles, in particular commercial vehicles, has, over the past few years, escalated considerably and is now a major concern. Some companies have investigated the problem but as yet a commercially viable security system has not emerged. During the last three years, the cost of diesel fuel in the UK has risen by over 30%.

In an attempt to avoid re-fuelling at expensive roadside filling stations, trucks often have enlarged fuel tanks carrying considerably more value in fuel. The high value and higher volumes carried, combined with the fact that there is little or no protection available for vehicle fuel tanks, have together encouraged considerable interest from the criminal fraternity. Fuel theft is now nationally a very serious problem, as stolen fuel is untraceable and commands up to 65% of retail value on the black market. This is a high percentage in comparison, for example, to 5% for a stolen car.

Most trucks can carry up to £450 in fuel and sometimes up to £800. Fuel is easy to steal, untraceable, and very marketable. Therefore, crime in this area

is increasing. Professional fuel thieves are now highly organised and mobile in specially adapted vehicles containing internal tanks or 45 gallon drums to transport and deliver stolen fuel. It is said that thieves now sell a truck tank of fuel for more than a stolen car. This is probably why fuel theft alone is now on a comparable level to vehicle crime in general.

A few security manufacturers have attempted to produce a reliable anti-theft device but none has proved a success. Such devices have included extra tough locking caps, but thieves simply prised these off with heavy duty screwdrivers or, alternatively, cut the fuel lines to access the fuel. Other devices, such as vibration tamper sensors, proved unreliable and continually gave false alarms. Steel mesh cones inserted inside fuel tank tops to physically prevent siphoning but allow input of fuel are stabbed through with jemmy bars to make a pathway for a siphon tube. Such mesh cones have the disadvantage that they cause fuel to froth excessively when the tank is filled.

The only product with limited success is a steel shroud, which is attached to hydraulic lifting truck bodies (tipper trucks) and covers the fuel tank top when the body is down. This system is inconvenient, since it is necessary to raise the whole truck body to fill the vehicle with fuel and as with the extra tough tank tops, thieves can simply cut fuel lines or cut through the shroud to steal fuel.

It is an object of the present invention to overcome the disadvantages of the prior art solutions.

It is a further object of the present invention to provide a cost-effective, accurate method of detecting liquid theft and leakage.

It is a further object of the present invention to detect tampering with parked vehicles.

It is a further object of the present invention to provide a device adapted for vehicle fleet management to detect when drivers of the fleet are appropriating fleet fuel for their own use.

According to a first aspect of the present invention, there is provided a device for monitoring change in liquid level comprising an input means for connection to an information sender, a processor for calculating change in liquid level over time and an output means for indicating when the change exceeds a defined threshold.

Surprisingly, it has been found that such device overcomes the disadvantages of the prior art and has many advantageous features. Since the device monitors change in liquid level in a tank over time, rather than the absolute quantity of liquid, it may be fitted in various systems without calibration or other special adjustments. Reference herein to change therefor indicates that the device monitors relative rather than absolute amounts of liquid.

Furthermore, monitoring the change over time, rather than instantaneous change in liquid level, means that fluctuations in liquid level due to movement of the tank, by wind, on ferries or by any other means, do not produce false alarms.

The present invention has particular applications in fleet vehicle management and can be used in conjunction with telematic techniques to monitor drivers who may be tempted to siphon fuel from their commercial vehicle for re-sale or their own private use or put company fuel into their private vehicle.

Reference herein to connection is to any suitable connection to allow a signal to be passed to the processor such as electrically, by fibre optics, by radio or other signal or by any mechanical means.

Reference herein to an information sender is to any suitable information sender that may form part of a fuel level sensor or be operatively connected thereto and receive a signal indicating the fuel level therefrom. Such a signal may be any suitable signal such as an electrical signal, for example a voltage, capacitance or any other measurable electrical property, or a measurable property of any other signal which may be used.

The liquid level of any tank reservoir or other system containing liquid may be monitored. Preferably the level is of liquid in a vehicle tank, more preferably a road vehicle tank.

Any suitable input means may be envisaged that allows input of the signal related to the fuel level. Preferably, a simple electrical connection is provided. More preferably, the connection is a switched connection so that the device may be activated and de-activated as hereinafter defined.

Any suitable processor may be provided for calculating change in liquid level over time. Thus, the processor is preferably provided with comparison means to hold and compare a number of signals separated in time. The processor is therefore preferably also provided with timing means.

For example, in a simple embodiment, the processor may be provided with comparison means to measure the signal at pre-determined time intervals and

store the values obtained. The comparison means functions such that if a certain number of values are each lower than the previous value, then the threshold is exceeded. Preferably these values are consecutive.

Preferably, the number of values is between 10 and 2, or preferably between 5 and 2 and ideally 3.

Any pre-determined time interval may be set by the timing means or the time interval may be adjustable by software or hardware changes. Preferably, the time interval is of between 0.5 and 5 seconds. More preferably, the pre-determined time interval is between 1 and 2 seconds.

Such a simple embodiment may be prone to false alarms due to temporary changes in liquid level or fuel level sensor inaccuracies. However, use of a long time interval and larger number of consecutive values may be sufficient to overcome this problem.

In a more complicated embodiment, the comparison means may incorporate further means such as averaging means to allow for sensor inaccuracies and vehicle movement.

The primary advantage in averaging is in lessening the effects of noise such as "spikes", for example transient voltage spikes which may be produced in the device by other parts or accessories of the vehicles such as winches, hazard lights or inaccuracies in the fuel level sensor on the final figure. Averaging thus increases accuracy of the system and decreases false alarms.

Any number of averaging steps may be used to eliminate false alarms from the system. Each step may average any number of values and use a median, mode

or other averaging method. In one preferred embodiment, the comparison means comprises a first averaging means calculating an intermediate average of original values, a second average means then finding the average of a number of the intermediate averages.

The first averaging means may be a mode averaging means and may function at least twice in each step to provide an average of a initial average which is then fed to the second averaging means which produces a final result for comparison.

Any number of values may be averaged in the at least one first averaging step. Thus, a first averaging means may average between 10 and 500 values and a second averaging means may average between 10 and 100 of the results from the first averaging means to produce an intermediate average.

The second averaging means may be a median averaging means or other further averaging means. For example, the second averaging means may be a simple averaging means which adds the lowest and highest value and divides these by 2 for any block of intermediate averages.

Any number of intermediate averages may be provided in a block of intermediate averages to obtain a sufficient number for averaging by the second and possible further averaging means. For example, a block may contain between 10 and 100 and preferably contains between 15 and 20 intermediate averages.

The final figure may be produced once for every block of intermediate averages or once every time a new intermediate average enters the block.

Thus, the block of intermediate averages may be in the form of a moving array with the oldest disappearing every time the newest is added to the block.

In such a more complicated embodiment, the pre-determined time interval may be of the order of milliseconds and is preferably between 0.1 and 100 milliseconds.

In a device as hereinbefore defined, the threshold may be defined in terms of a maximum number of final figures, each lower than the previous, or a maximum change between final figures, or a combination of the two such that a certain number of final figures must be lower than the previous final figure by a certain (perhaps averaged) amount.

In a device as hereinbefore defined, any suitable output means may be provided that can at least output information as to the exceeded threshold. The output means may also be responsible for general monitoring and may thus provide information even when the threshold has not been exceeded.

In one simple embodiment, the output means may be an alarm of any form such as a light or siren on the vehicle or provided separately, a vibration, display, whether in the vehicle or elsewhere, or any other form of alarm. Alternatively, the output means may merely form the connection to such an alarm.

Additionally or alternatively, the output means may comprise a storage and/or transmission means for information which may be downloaded from the device continuously or at intervals by use of conventional techniques, such as transmission by electronic, radio, optical or other suitable signals. For

example, the output means may comprise a radio pager or GSM modem connected to a central monitoring station.

This embodiment is particularly suited to use by the manager of a fleet of vehicles such that the driver need not be aware of the device but information as to possible fuel theft is nevertheless provided. The download may be automatic or manual and need not require physical connection to the device.

The device as hereinbefore defined may be continuously in operation or provided with activation and de-activation means. Any suitable activation means may be provided such as a manual on/off switch or an automatic activator that switches the device on when certain conditions are fulfilled.

For example, the automatic activator may activate the device when it detects that the vehicle is not in use. Such detection may involve a motion sensor, comparison of GPS values, indication as to when the ignition is off, a pressure switch in the oil system (since oil pressure will decrease when the vehicle is not in use) or any other suitable input.

The device may be continually in operation but only produce an output when the threshold is exceeded at an unauthorised time as defined by the automatic switch inputs above.

The device may further comprise delay means such that there is a pre-defined time delay before the device begins monitoring. Such delay can be valuable in allowing the fuel level to settle into a stable condition.

Any length of delay may be set suitably to allow fuel to settle. Preferably, the delay is of between 1 and 5 minutes and more preferably is approximately 3 minutes.

The device may also comprise an on/off indicator, such as an LED or other light or display to indicate functioning of the device. For example, a flashing LED may be employed that flashes on or off for each final figure is obtained.

In one preferred embodiment, the device as hereinbefore defined may be incorporated into the existing fuel gauge system of a vehicle. In this embodiment, the device is preferably connected between the existing information sender and the fuel level readout in the cab, by use of standard wiring. Use of the existing system allows a quick and simple retrofit to a vehicle with the minimum of additional parts.

In this preferred embodiment, diversion means are preferably provided such that the signal from the fuel level sensor is diverted to the device when the device is activated and passes to the fuel level readout in the cab when the device is not activated. A combined diversion and activation means may be, for example, a relay.

Alternatively, the device may provide partial diversion means such that the signal may pass both to the fuel level readout and to the device at any given time.

In an alternative embodiment of the device as hereinbefore defined, the device may comprise the information sender and/or fuel level sensor. Thus, an additional fuel level sensor and/or information sender is fitted to the truck so

that the device does not rely on the pre-fitted system. Such a preferred embodiment may be advantageous in terms of improved security and less likelihood of tampering.

The fuel level sensor, whether part of the device or part of the truck fuel system, may be any suitable fuel level sensor such as a pressure sensor, float sensor, capacitance sensor, ultra-sonic sensor, or other conventional sensor.

The information sender unit is any known from conventional techniques and usually comprises a potentiometer whose resistance is determined by the position of an arm which moves with a float and produces an electrical potential corresponding to the position..

The device may also be connected to other inputs or be formed as part of a larger device, such as a tachometer or a fully featured alarm system for vehicle theft or damage including, for example further sensors positioned in other parts of the vehicle.

For example, the device may comprise input means for a level reference monitor which monitors the level of the truck axis. The device may also comprise a level reference monitor, which is of any suitable construction. Level comparison means for comparison with the level of the truck may be provided such that the final figure for the liquid level is modified if the truck is tilted for any reason such as wind movement, removal of wheels, movement on a ferry or unloading of goods from the vehicle.

Additionally or alternatively, the device may comprise input means for a fuel pump monitor, so that the amount of fuel dispensed to the driver of a vehicle from the pump may be compared to a change in level in the vehicle tank.

The device may be powered by any conventional means and is preferably powered using the vehicle battery.

Where the output means stores information for periodic downloading in readable memory, means may be provided to quantify the change in liquid level. Thus, the threshold of the device as hereinbefore defined will vary according to the size of the tank and properties of the fuel level sensor.

Therefore, each vehicle type requires calibration of the device if absolute measurements of fuel removal are required. Therefore, the device may further comprise a calibration module which may be calibrated to link the values obtained from the information sender to absolute quantities of fuel.

The calibration module may be physically separated from or form part of the device and provided as software or as hardware. In one preferred embodiment, the calibration module is provided as PC software. In this case, the device is activated if necessary and the output means connected to the calibration module. The fuel level sensor is then put in its maximum and minimum positions to calibrate the tank size. In the case of a float level sensor, this is easily achieved. In a further calibration step, a pre-determined quantity of fuel may be siphoned from the tank and this may be entered into the calibration system.

In a further aspect of the present invention, there is provided a device for monitoring the change in liquid level comprising input means for connection to an information sender provided as part of the fuel gauge system in a vehicle, a processor for calculating change in liquid level over time, and an output means for indicating when the change exceeds a defined threshold.

There is further provided the use of fuel level information from the fuel level sensor of a fuel tank to activate a security device as hereinbefore defined.

In a further aspect of the present invention, there is provided a method of monitoring change in liquid level comprising connection of a device as hereinbefore defined to a vehicle or other system which is to be monitored.

In a further aspect, there is provided a method of manufacture of a device as hereinbefore defined comprising assembly of an input means, a processor, and an output means, and any further optional means as hereinbefore defined.

Further advantages of the invention will be obvious from the foregoing.

The following figures illustrate a non-limiting, preferred embodiment of the invention.

Figure 1 shows a general layout of a vehicle including the device.

Figure 2 shows a functional block diagram of the processor.

Figure 3 shows a circuit diagram of the device.

In Figure 1 is shown a fuel storage tank (1) as fitted and installed in most automotive vehicles. Attached to the fuel tank is an information sender unit (2) that protrudes into the fuel tank (1). A fuel level sensor (3) in the form of a float transmits information as to the liquid level to the information sender (2) which, in general, transmits a corresponding signal to the fuel level readout or fuel gauge (4). The information sent affects the reading of the gauge and

informs the vehicle user of the amount of fuel stored in the tank (1). As the fuel level decreases, the information sent changes, resulting in a change of the reading of the fuel gauge (4).

The device, according to the present invention (5) is installed between the fuel tank (1) and fuel gauge (4) to receive information from the information sender unit (2) and will detect changes in fuel level from the information sent. If this occurs when the device is operational or when the device is operational and at an unauthorised time, output means () will be activated to produce an alarm or other signal.

Figure 2 shows a functional block diagram of the software in one preferred embodiment which is built into the device. Module 1 converts the incoming signal to digital format and provides a mean of 256 values. In module 3, a mean of 32 of these results is provided. The mean is entered as the most recent in a block of modes which is shown in module 2. Module 1 monitors the average window which is formed from a 16 place block and sets an alarm flag where the value of one block (calculated as the highest plus the lowest mode divide by 2) is considerably lower than the previous block.

Module 4 controls the LED output which indicates a division of the device and the alarm output.

Figure 3 is a circuit diagram showing connections to the information sender and fuel gauge as well as the ignition circuit.

Reference numerals

1. Fuel storage tank.
2. Information sender.
3. Fuel level sensor.
4. Fuel gauge/fuel level readout.
5. Device

Claims

1. A device for monitoring change in liquid level comprising an input means for connection to an information sender, a processor for calculating change in liquid level over time and an output means for indicating when the change exceeds a defined threshold.

2. A device as claimed in claim 1 wherein the level monitored is of liquid in a vehicle tank, more preferably a road vehicle tank

3. A device as claimed in claim 1 or 2 wherein the input means comprises a simple electrical connection, preferably switched.

4. A device as claimed in any of claims 1 to 3 wherein the processor is provided with comparison means and timing means to hold and compare a number of signals separated in time by predetermined time intervals.

5. A device as claimed in any of claims 1 to 4 wherein the comparison means functions such that if a certain number of preferably consecutive values are each lower than the previous value, then the threshold is exceeded.

6. A device as claimed in claim 4 or 5 wherein the comparison means incorporates further means such as averaging means to provide final figures for comparison.

7. A device as claimed in any of claims 4 to 6 wherein the comparison means comprises a first averaging means calculating an intermediate average of original values, a second average means then finding the average of a number of the intermediate averages.

8. A device as claimed in any of claims 4 to 7 wherein the pre-determined time interval is of the order of milliseconds and is preferably between 10 and 100 milliseconds.

9. A device as claimed in any of claims 6 to 8 wherein the threshold is defined by a maximum number of final figures, each lower than the previous, or a maximum change between consecutive final figures, or a combination of the two such that a certain number of final figures must be lower than the previous final figure by a certain amount.

10. A device as claimed in any of claims 1 to 9 wherein the output means is an alarm such as a light or siren on a vehicle or a connection thereto.

11. A device as claimed in any of claims 1 to 9 wherein the output means is a read-out or a storage and/or transmission means for information which may be downloaded from the device continuously or at intervals.

12. The device as claimed in any of claims 1 to 11 further comprising with activation and de-activation means.

13. The device as claimed in any of claims 1 to 12 further comprising an automatic activator to activate the device when it detects that the vehicle is not in use.

14. The device as claimed in claims 12 or 13 further comprising a delay means such that there is a pre-defined time delay before the device begins monitoring.

15. The device as claimed in any of claims 1 to 14 comprising means for its connection between the existing information sender and the fuel level readout of a vehicle.

16. The device as claimed in claim 15 wherein diversion means are provided such that the signal from the fuel level sensor is diverted to the device when the device is activated and passes to the fuel level readout when the device is not activated.

17. The device as claimed in any of claims 1 to 13 further comprising an information sender and/or fuel level sensor.

18. The device as claimed in any of claims 1 to 13 further comprising a level reference monitor which monitors the level of the truck axis or an input means for a level reference monitor.

19. The device as claimed in any of claims 1 to 18 further comprising a calibration module which may be calibrated to link the values obtained from the information sender to absolute quantities of fuel.

20. A device for monitoring the change in liquid level comprising input means for connection to an information sender provided as part of the fuel gauge system in a vehicle, a processor for calculating change in liquid level over time, and an output means for indicating when the change exceeds a defined threshold.

21. The use of fuel level information from the fuel level sensor of a fuel tank to activate a security device as hereinbefore defined.

22. A method of monitoring change in liquid level comprising connection of a device as hereinbefore defined to a vehicle or other system which is to be monitored.

23. A method of manufacture of a device as hereinbefore defined comprising assembly of an input means, a processor, and an output means, and any further optional means as hereinbefore defined.

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Claims searched: 1-20 and 22 **Date of search:** 17 September 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): G1N (NACK, NAHHB, NAHHK, NAHK)

Int Cl (Ed.6): B60R 25/10, G01D 1/16, 1/18, G01F 23/00, 23/36, G01M 3/26, 3/32

Other: ONLINE : WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,Y	EP 0650875 A1	(MOTOROLA) whole document relevant	X:1-4, 10,12-14, 17,20,22 Y:6,14,18
Y	EP 0650033 A1	(ROBERT BOSCH)	14
X	US 5056017	(MCGARVEY) whole document relevant	1,3, 4,11, 17-19,22
X,Y	US 4827762	(HASSELMANN) see Figure 1	X:1,3,4, 11,17, 19,20,22 Y:6
Y	US 4359717	(HUBER ET AL) see Figures 1&4	18
X,Y	US 4353245	(NICOLAI) whole document relevant	X:1,3, 4,8,10, 17,18,22 Y:6,14,18

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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Application No: GB 9913240.9 **Examiner:** Mark A Pullen
Claims searched: 1-20 and 22 **Date of search:** 17 September 1999

Category	Identity of document and relevant passage		Relevant to claims
X,Y	DE 4422889 A1	(TELEFUNKEN) see Abstract and Figures 1&2	X:1-3, 10,11, 17,20,22 Y:6,14,18
X,Y	DE 3429494 A1	(DAIMLER-BENZ) see Abstract and Figure 1	X:1-4, 10,12, 17,20,22 Y:6,14,18
X,Y	JP 620120244 A	(OMRON) see Abstract and Figure 1	X:1-6, 10,12, 17,20,22 Y:6,14,18
X,Y	JP 090257551 A	(YAZAKI) see Abstract and Figure 1	X:1-6, 11,12,17, 19,20,22 Y:6,14,18

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.